

ESDIS

Level 1 Product Generation System (LPGS)

Operations Concept

February 1997

Prepared Under Contract NAS5-31000/HQ001057
By Computer Sciences Corporation
CSC 10034093

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Preface

The contents of this document were presented at the combined internal Level 1 Product Generation System (LPGS) Project system requirements review (SRR) and system design review (SDR). This document is maintained and controlled by the LPGS Project Configuration Management Board (PCMB) and can only be updated or revised on approval by the PCMB. Comments and questions regarding this document should be directed to

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Abstract

The Level 1 Product Generation System (LPGS) operations concept describes how the LPGS will be operated within the Earth Observing System (EOS) Ground System (EGS) to provide Land Satellite 7 (Landsat 7) Enhanced Thematic Mapper Plus (ETM+) systematically corrected digital images to EOS Data and Information System (EOSDIS) Core System (ECS) customers. The LPGS operations concept also provides a topology for the LPGS architecture and describes the interfaces to external elements. The concepts are derived from the Earth Sciences Data and Information System (ESDIS) Project Mission-Specific Requirements for the Landsat 7 Mission Level 1 Processing system document, and they are consistent with the ECS to Landsat 7 System interface control document (ICD).

Keywords: *Distributed Active Archive Center (DAAC), Earth Observing System Data and Information System (EOSDIS), EOSDIS Core System (ECS), Earth Resources Observation Satellite (EROS) Data Center (EDC), Landsat 7, Level 1 product, Level 1 Product Generation System (LPGS)*

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Document Number	Status/Issue	Publication Date	CCR Number
510-3OCD/0296 CSC 10034093	Original	February 1997	NA

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Section 1. Introduction

1.1 Operations Concept Scope

The operations concept describes how the Level 1 (L1) Product Generation System (LPGS) will be operated within the Earth Observing System (EOS) Ground System (EGS) and will interface with the Land Satellite 7 (Landsat 7) System and other EGS elements. The LPGS produces radiometrically and systematic geometrically corrected digital images of data collected by the Landsat 7 Enhanced Thematic Mapper Plus (ETM+). The concepts presented are responsive to the Earth Sciences Data and Information System (ESDIS) Level 2 requirements documented in the ESDIS Mission-Specific Requirements for the Landsat 7 Mission L1 Processing (Applicable Document 9).

1.2 Applicable Documents

Information from the following documents was used in developing the LPGS operations concepts:

1. EOSDIS Core System Project, 223-CD-001-002, *ECS External Data Traffic Requirements*, August 1996
2. --, 604-CD-002-003, *ECS Operations Concept for the ECS Project: Part 2B - ECS Release B*, March 1996
3. --, 209-CD-013-003, *Interface Control Document (ICD) Between ECS and the Landsat 7 System*, March 1996
4. --, 305-CD-027-002, *Release-B SDPS Data Processing Subsystem Design Specification*, March 1996
5. --, 604-CD-003-002, *ECS Operations Concept for the ECS Project: Part 2A - ECS Release A*, November 1995
6. --, 305-CD-029-002, *Release B CSMS System Management Subsystem Design Specification for the ECS Project*, July 1994
7. --, 194-207-SE1-001, *System Design Specification for the ECS Project*, June 1994
8. --, 305-CD-024-002, *Release B SDPS Data Server Subsystem Design Specification for the ECS Project*
9. National Aeronautics and Space Administration (NASA), Goddard Space Flight Center (GSFC), *Earth Sciences Data and Information System (ESDIS) Mission-Specific Requirements for the Landsat 7 Mission L1 Processing*, Draft, September 1996
10. --, *Landsat 7 L1 Product Generation System (LPGS) Project Management Plan*, Draft, May 1996
11. --, 514-IICD/0195, *ICD Between IAS and LPS*, January 31, 1996

12. --, 560-3OCD/0194, *Landsat 7 Processing System (LPS) Operations Concept, Revision 2*, April 15, 1996
13. --, 505-41-18, *IRD Between EOSDIS and MITI ASTER GDS Project*, July 1995
14. --, 505-41-13, *IRD Between EOSDIS and the Landsat-7 System*, July 1995
15. --, *Landsat 7 Detailed Mission Requirements*, May 1995
16. --, *IAS Operations Concept*, December 19, 1994
17. --, 430-15-01-001-0, *Landsat 7 System IAS Element Specification, Baseline*, September 17, 1996
18. --, NHB 2410.9A, *NASA Automated Information Security Handbook*, June 1993
19. --, 505-10-23, *ESDIS Security Policy and Guidelines*, March 1996

1.3 Definitions

The following terms, as defined in this section, are commonly used throughout this document to describe the LPS operations concept:

- Level 0R (L0R) digital image—Reformatted, unrectified subinterval data
- Level 0R (L0R) product—The L0R digital image plus radiometric calibration, attitude, and ephemeris data, consisting of the following files:
 - L0R digital image
 - Internal calibrator (IC) data—Calibration data file containing all the calibration data received on a major frame basis for a given subinterval
 - Mirror scan correction data (MSCD)—The scan direction and error information for a given subinterval
 - Payload correction data (PCD)—Information on spacecraft attitude and ephemeris, including quality indicators for each subinterval
 - Browse image—A reduced data volume file of the L0R data that can be viewed to determine general ground area coverage and spatial relationships between ground area and cloud coverage
 - Metadata—Descriptive information about the L0R image, names of appended files associated with the image, and quality and accounting information.
 - Calibration parameter file—A formatted file containing gains, biases, and offsets for the instrument and detectors.
- Level 1R (L1R) digital image—Radiometrically corrected but not geometrically resampled

- Level 1G (L1G) digital image—Radiometrically corrected and resampled for geometric correction and registration to geographic map projections
- Production quality assessment—Ancillary information collected and generated during L1 processing; provides information on the certainty with which corrections were made to images; nominally included in the L1 product file or metadata
- Interval—The time duration between the start and stop of an imaging operation (observation) of the Landsat 7 ETM+ instrument
- Subinterval—Segment of time corresponding to a portion of an observation within a single Landsat 7 contact period
- Worldwide Reference System (WRS) scene—Digital image that covers an area equivalent to one of the 57,784 scene-centers (233 paths x 248 rows areas) defined by the WRS structure

1.4 LPGS Environment

The LPGS is a source of ETM+ L1 data within the EGS, shown in the EGS overview (Figure 1-1). The EGS is a collection of ground support elements for EOS and includes the EOS Data and Information System (EOSDIS), institutional support elements, affiliated and international partner data centers, international partner instrument control and operations centers, and other sources of data. The LPGS is located at the Earth Resources Observation Satellite (EROS) Data Center (EDC) Distributed Active Archive Center (DAAC) and provides ETM+ L1 product generation and distribution services on a demand basis. The LPGS receives L1 product generation requests and distributes generated products to customers through the EOSDIS Core System (ECS) at the EDC DAAC on a first in, first out (FIFO) basis. The LPGS is the responsibility of the ESDIS Project and will be developed at the Goddard Space Flight Center (GSFC) and installed at the EDC DAAC to provide product generation and distribution support for a Landsat 7 minimum mission life of 5 years.

1.4.1 Landsat 7 Image Collection and Production End-to-End Data Flow

Figure 1-2 shows the flow of data from the Landsat 7 platform and ETM+ instrument to customers. The Mission Operations Center (MOC) plans and schedules ETM+ data collection and downlink based on mission objectives of refreshing the global archive, weather and orbit information, spacecraft constraints, and acquisition requests received from international ground stations (IGSs). IGSs' requests routinely include data collection for all land mass coverage within the station's field of view. The MOC transmits spacecraft commands to the Landsat ground network (LGN) for uplink to the Landsat 7 platform and the ETM+ instrument. The ETM+ instrument collects images over land masses and either records image data on an onboard solid state recorder (SSR) for downlink when in sight of a ground station, or downlinks data in real time to the Landsat 7 ground station (LGS) or IGS. The LGS can simultaneously receive SSR

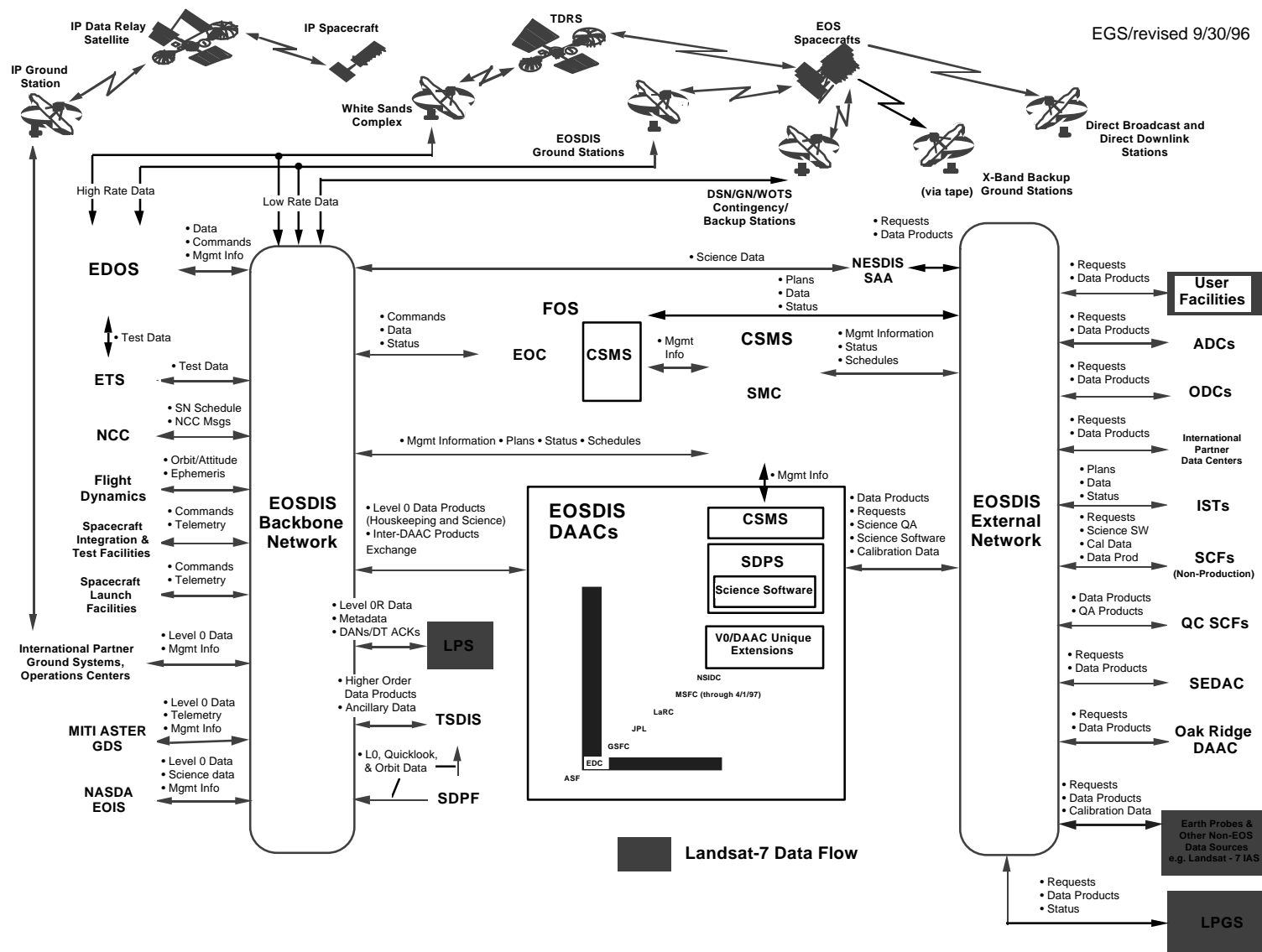


Figure 1-1. EGS Overview

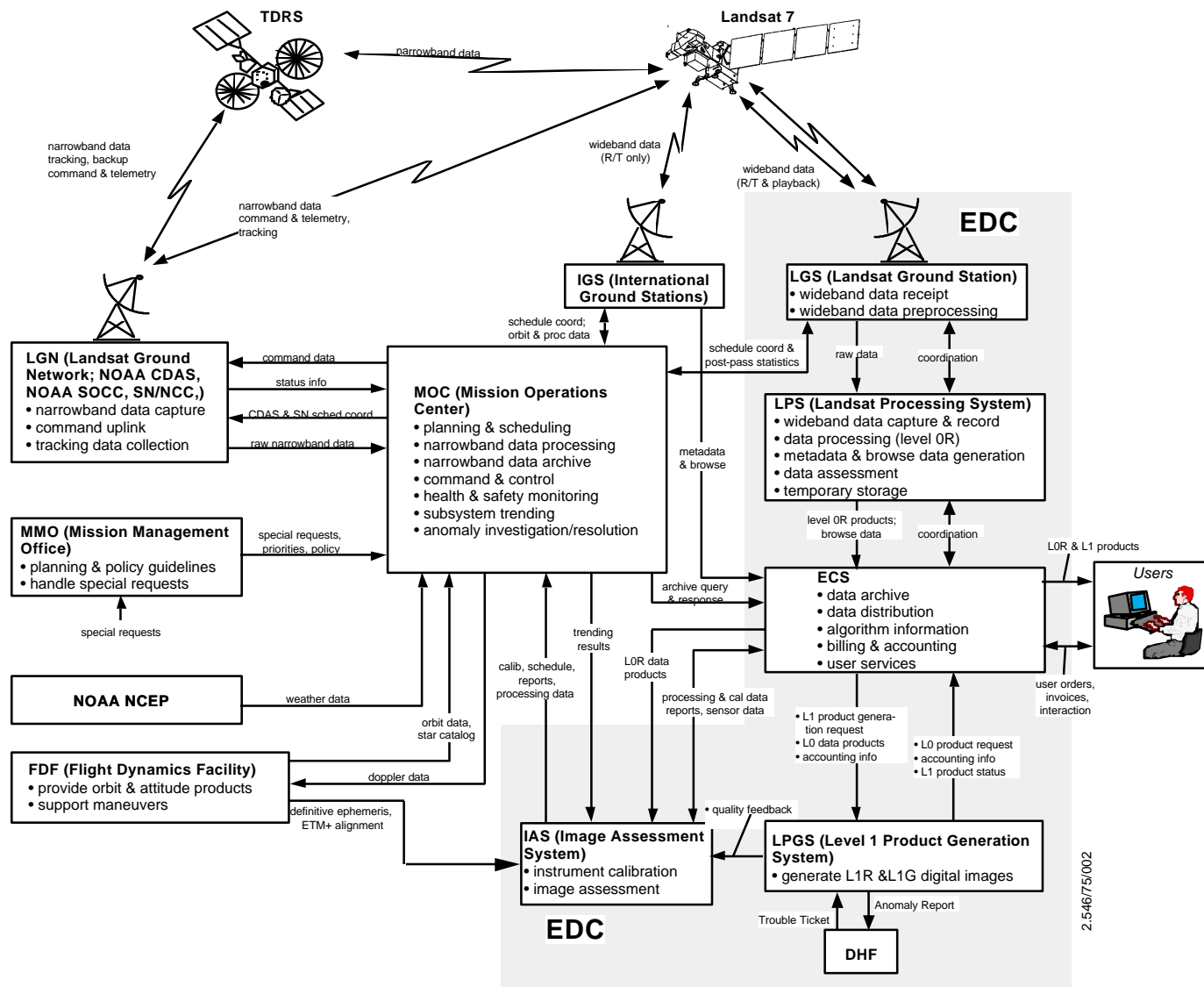


Figure 1-2. Landsat 7 Data Flow

and real-time data downlink. The LGS transmits raw data to the Landsat Processing System (LPS), which produces reformatted Level 0 (L0R) data and browse and inventory metadata that are transmitted to the EDC DAAC for archive. IGSs produce higher level products from the downlinked, wideband data and periodically transmit browse and inventory metadata to the EDC DAAC for archive. Customers access the ECS search and order facilities and query the availability of ETM+ products. L0R and IGS product metadata and browse images can be accessed and viewed to identify desired products. Customers submit requests for IGS products directly to the IGSs, which are responsible for distributing their products directly to the customer. Customers submit orders for standard L0R products and requests for generation of L1 products through the ECS interface. Requested L0R data are extracted from the EDC DAAC and directly distributed to the customer in response to the customer's product request. The ECS component at the EDC DAAC submits L1 product generation requests to the LPGS in response to customer requests for L1 data. The LPGS creates L1 digital images and associated files and distributes them to the ECS in response to the product generation request. The ECS in turn distributes the requested L1 products to the customer.

1.5 LPGS Goals and Objectives

LPGS concepts have been developed in accordance with project goals of maintaining system and operations cost and development schedule objectives and of reducing risks. LPGS concepts will accommodate an additional goal of employing common algorithms for initial Image Assessment System (IAS) and LPGS releases. Concepts that include allocation of requirements to existing or concurrently developed systems have been analyzed and have been adopted based on tradeoff analyses.

1.6 Assumptions

1.6.1 LPGS Daily Production

The requirement for LPGS daily production of WRS scenes is defined as the production of a spatial equivalent of 25 digital WRS scene images, each of which covers an area equivalent to one of the 57,784 scene-centers (233 paths x 248 rows areas) defined by the WRS structure. Individual L1 product generation requests from the ECS can be received for processing images of a multiple scene or partial subinterval, up to a 3 WRS scene equivalent, a WRS scene, a Shift Along Track (SAT) scene, and geographic frames of L0R data that reside in the EDC DAAC.

1.6.2 Standing Order Processing

The LPGS will request L0R data and will produce L1 images only upon receipt of an L1 product generation request from the ECS. The L1 product generation request must be based on or derived from L0R data that currently reside in, and are available for transmission from, the EDC DAAC working storage or archive. The L0R data must be specifically identified by date and partial subinterval or scene according to the naming convention used when querying ECS inventory. The LPGS will have no insight into categorization of product requests as "standing orders" or "subscriptions."

1.6.3 Geometric Correction

The LPGS will not perform precision correction or terrain correction for ground control points during L1G production. The LPGS will, however, perform resampling for geometric correction and geographic registration to map projections.

1.6.4 L0R Image Quality

L0R images must meet TBD quality standards for successful L1 product generation. Metadata may be analyzed to identify the quality of L0R images when L1 products fail production quality assessments.

Section 2. LPGS Overview

The LPGS is the EGS element that produces both radiometrically and systematic geometrically corrected digital images from data collected by the Landsat 7 ETM+ instrument. Key aspects of the operations and interfaces of LPGS, shown in Figure 2-1, are presented in the sections below.

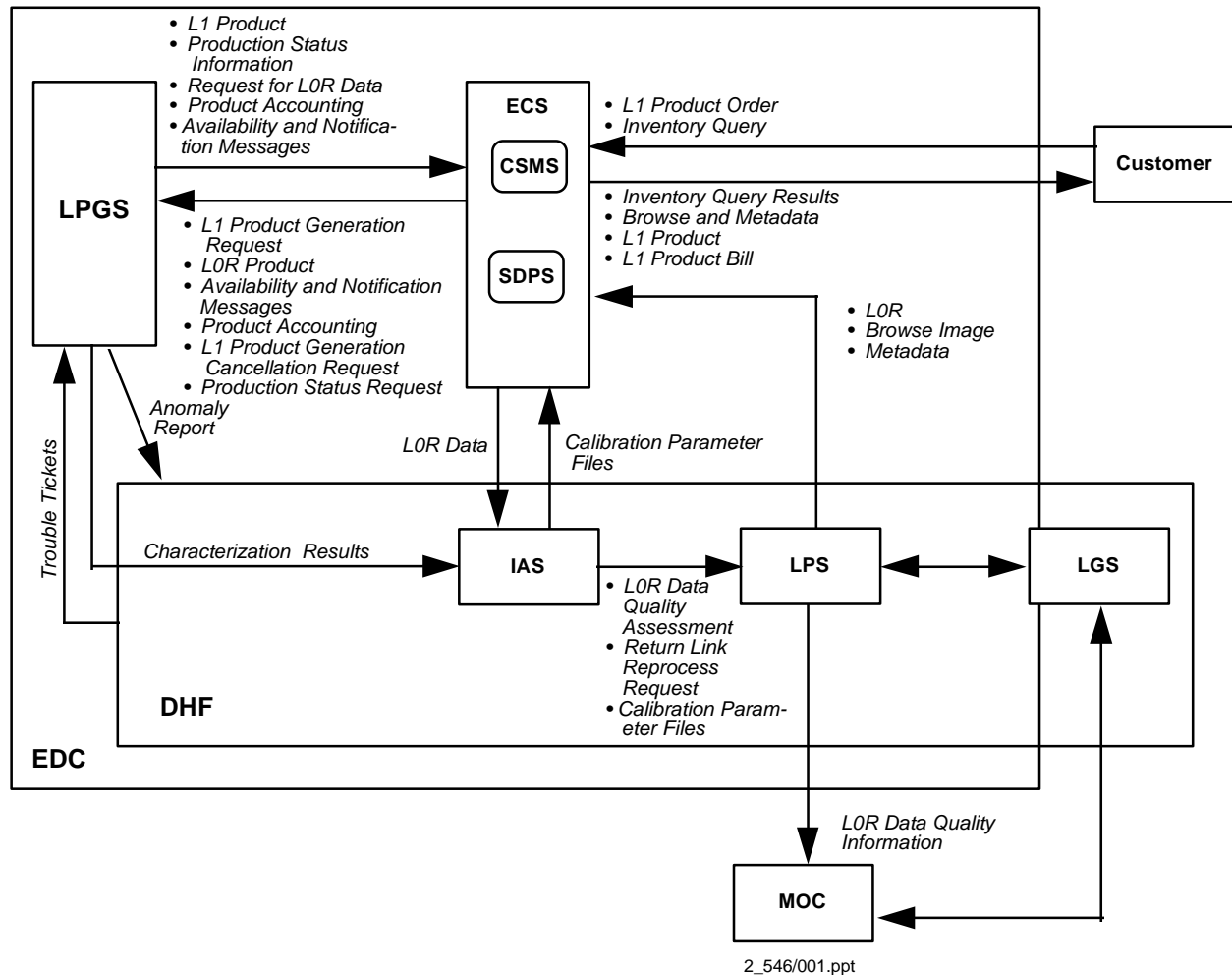


Figure 2-1. LPGS Context

2.1 LPGS Description

The LPGS produces L1 data products in electronic format corresponding to a WRS scene or partial ETM+ subintervals based on customer requests. The LPGS is capable of producing a daily volume of 25 WRS scenes of L1G, radiometrically corrected and digitally resampled for geometric correction and geographic registration. LPGS can create digital images projected to different coordinate reference systems, for any subset of the eight spectral channels collected by

the ETM+ instrument, or in different output formats according to other options specified in the customer's requests. LOR data are requested from the ECS, and appended calibration parameter, PCD, and MSCD files are applied by the LPGS in producing L1 data products.

The L1 product is provided to the ECS. The ECS distributes the entire L1 product (including L1 digital image calibration parameter file data, PCD, MSCD, and metadata) to the customer.

2.2 External Interfaces

The interface between the LPGS and ECS, IAS, and the Landsat 7 Data Handling Facility (DHF) are described below. Table 2-1 provides a summary of inputs and outputs.

Table 2-1. LPGS External Interfaces

Element Interface	Inputs to LPGS	Outputs From LPGS
ECS	<ul style="list-style-type: none"> • L1 product generation request • Production status request • LOR data product • Accounting for L1 product distribution • L1 product generation cancellation request 	<ul style="list-style-type: none"> • LOR product request • L1 product • Production status information • L1 product accounting information
IAS		<ul style="list-style-type: none"> • Characterization results
DHF	<ul style="list-style-type: none"> • Trouble ticket information 	<ul style="list-style-type: none"> • Anomaly report

2.2.1 Interface to ECS

The primary LPGS interface is with the ECS within the EDC DAAC. The LPGS receives L1 product generation requests from the ECS. L1 product generation requests are processed by the LPGS, which submits a LOR product request to the ECS. The LPGS then electronically retrieves LOR products, including calibration parameter files, in response to the request. During L1 data generation, the LPGS generates production status information. Production status may be distributed to the ECS in response to production status requests transmitted to the ECS by customers. After completion of L1 processing, the images and other pieces of the L1 product are electronically provided to the ECS. Accounting information for L1 production is exchanged with the ECS periodically. The ECS may transmit an L1 product generation cancellation request to terminate processing of previously transmitted product generation requests.

2.2.2 Interface to IAS

During L1 image processing, various characterizations for effects from saturated detectors, coherent noise, and memory effects are performed. The LPGS collects results of characterizations and periodically distributes them to the IAS for trending and further analysis.

2.2.3 Interface to DHF

The LPGS maintains an interface to the DHF for receiving trouble tickets and forwarding anomaly reports. Some anomalies identified in ECS trouble tickets or LPGS postproduction analysis cannot be attributed to the L1 production generation request, processed LOR image, or the L1 production process, and they cannot be resolved by LPGS production analysts. The available information about these anomalies is forwarded to the DHF in the form of an anomaly report.

2.3 Functional and Operational Capabilities

This section describes the high-level functions performed by the LPGS.

2.3.1 Receive and Process L1 Product Generation Requests

The LPGS receives L1 product generation requests from the ECS science data processing segment (SDPS) component. The L1 product generation requests are processed by the LPGS to extract customer parameters and options and the identifiers for LOR products that will be processed.

2.3.2 Plan L1 Data Production

The LPGS adds L1 product generation requests into the L1 processing queue. Processing resources are allocated for the requested L1 data production on a FIFO basis, although product generation requests can be promoted in the processing queue. LPGS provides the operator with the capability to manually promote work orders within the processing queue. This capability allows operators to control the production queue to accommodate work shift staffing modifications and reduce impacts on the production flow of work orders that require more intensive processing.

In the case of requests to cancel previously scheduled processing that has not yet commenced, resources can be deallocated. Information is extracted from the processing queue status and distributed as production status reports to the ECS periodically or in response to production status requests. The information provides feedback on projected and completed processing.

2.3.3 Request and Receive LOR Products

The LPGS creates a request for LOR data based on the status of the L1 processing queue. The LPGS transmits the LOR product request to the ECS. In response, the ECS “pushes” the LOR product to the LPGS, including the appended files, and places the data in the LPGS temporary storage area until processing occurs. LOR data are purged from the storage area after processing, including data quality verification, is completed and the storage limit is attained.

2.3.4 Generate Radiometrically and Geometrically Corrected Digital Images

2.3.4.1 Generate L1R Data

The LPGS retrieves L0R data and applicable appended files from temporary storage and generates radiometrically corrected digital images by applying the customer-specified parameters.

2.3.4.2 Generate L1G Data

According to customer-specified parameters, the LPGS resamples L1R data for geometric correction and geographic registration to map projections.

2.3.4.3 Collect Performance and Data Quality Information

Based on operator-specified options and thresholds, the LPGS performs and can store results from quality checks when processing and formatting digital images. Based on operations shifts, operator-specified options, and previous quality feedback, visual inspection of products can be performed after processing and final product formatting. Nominally, L1 products are generated without operator intervention. The LPGS generates information that provides an assessment of data quality and accuracy of a produced image and an indicator of production processor performance for specified time periods or work orders. Data and performance assessment reports can be generated from the information and accessed by production operators for real-time analysis during production runs. Results and statistics from characterizations performed during image processing are periodically distributed to the IAS.

2.3.4.4 Reprocess Requests

L0R data can be reprocessed because of unacceptable quality assessments of L1 production images before distribution of L1 products to the ECS. A small portion of the available resources is reserved to accommodate these types of reprocessing runs. Data reprocessing runs, in response to trouble tickets and product anomalies detected by the customer, are added to the production queue and may be promoted in the processing queue if necessary.

2.3.5 Distribute L1 Product

The LPGS provides L1 products to the ECS for final distribution to customers. Table 2-2 details the L1 product components. LPGS notifies the ECS that data are available for retrieval. Production status reports are distributed to the ECS periodically and at customer request.

2.3.6 Distribute and Receive Product Accounting Information

The LPGS distributes product processing and accounting data to the ECS. The LPGS periodically receives distributed accounting information for products from the ECS.

Table 2-2. L1 Product Contents

Component	HDF-Format		FAST/GEOTIF F
	L1R	L1G	L1G
L1 digital image	X	X	X*
Calibration parameter file	X	X	
PCD	X		
MSCD	X		
Metadata (including processing quality information)	X	X	
Internal calibrator data	X		
Geolocation table	X	X	

* Format embeds metadata and attitude/ephemeris information in file that contains image.

2.4 LPGS Reference Architecture

Trade-off analyses resulted in selection of an LPGS reference architecture in which the LPGS is a system within the EGS that is external to the ECS.

2.4.1 Functional Areas

This topology is based on partitioning the LPGS into several functional areas. A description of each area and a list of the high-level functions it performs are provided below.

- Production planning
 - Product generation request and cancellation request processing
 - Production queueing
 - L0R product request generation
 - Production status report generation
 - Resource allocation and deallocation
- Image processing
 - L1R product generation
 - L1G product generation
 - Production quality assessment collection and report generation
 - Characterization statistic generation
 - Anomaly resolution analysis
 - Reprocessing

- Distribution and message transmission
 - L1 product distribution
 - Characterization statistics distribution
 - Anomaly report distribution
 - Production status and product result status report distribution
 - L0R product request transmission
 - Product accounting distribution
- Message receipt and ingest
 - L1 product generation request receipt
 - Cancellation request receipt
 - L0R product ingest
 - Production status request receipt
 - Product accounting receipt
 - Trouble ticket receipt
- Storage
 - L0R product temporary storage
 - L1 image and production quality temporary data storage
- Accounting and management
 - L1 product accounting
- Development, test, and maintenance
 - System development
 - System integration and test
 - Training support

2.4.2 Reference Topology

Figure 2-2 depicts an architecture in which the LPGS is a standalone system, independent of the ECS. The LPGS message receipt and ingest functions maintain an interface with the ECS data server subsystem (DSS) for receipt of L0R data and L1 product generation requests. The ECS Insert Service interfaces with the LPGS distribution and message transmission functions to retrieve the L1 images and production quality information. An interface between the LPGS billing, accounting, and management subsystem is established with the management subsystem (MSS) for

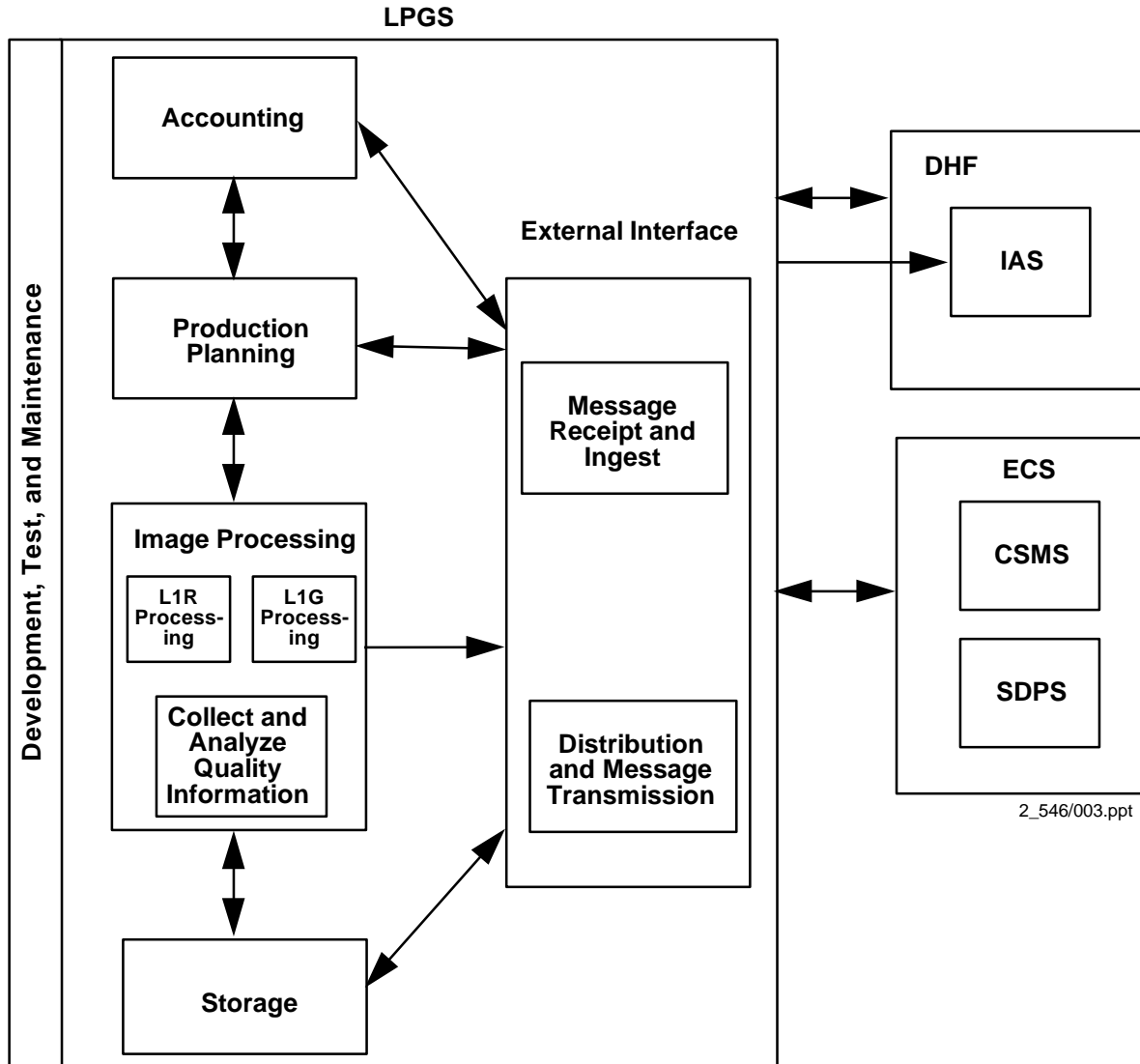


Figure 2-2. LPGS

the exchange of product distribution accounting data. The LPGS distribution and message transmission functions require an interface with the IAS for transmission of characterization statistics and an interface with the DHF for exchange of anomaly reports and trouble tickets.

2.5 LPGS System Support

This section documents peripheral or supporting requirements, including training and maintenance needs, that affect system design. Updates to the radiometric and geometric correction algorithms are provided to the LPGS development, test, and maintenance functions for testing and baseline integration. Updated algorithms are integrated into the image processing software in accordance

with configuration control guidelines and project maintenance and sustaining engineering operations procedures. Procedures will be developed to avoid lengthy configuration change request (CCR) approval and documentation cycles, when needed, to allow expedited modification to operational algorithms to limit impacts on the production schedule and image quality.

2.6 Security

The LPGS architecture and operations will comply with security requirements and procedures established in the NASA *AIS Handbook* (Applicable Document 18) and the *ESDIS Security Policy and Guidelines* (Applicable Document 19).

Section 3. LPGS Operations

LPGS operations have been allocated to three different phases of activities: preproduction, production, and postproduction. The preproduction phase includes production planning, scheduled system maintenance, algorithm integration, and product request processing in preparation for L1 data production. The production phase includes the actual processing of L0R data to create systematically corrected digital images. This phase includes generation of real-time data and production quality assessments that can be visually inspected or automatically monitored during various stages of product generation. The postproduction phase includes generation of product and production quality assessment and characterization results reports and distribution of L1 images and accounting information. All phases include both automatic and manually performed activities.

3.1 Performance Requirements

Tables 3-1 and 3-2 summarize LPGS input, production, and distribution requirements derived from the L2 requirements, and the IRD between EOSDIS and the Landsat 7 System (Applicable Document 14). Data volumes are derived from image volumes contained in the IAS Element Specification (Applicable Document 17).

Table 3-1. LPGS Input Requirements

Data	Interface	Volume
L0R product image	ECS SDPS	14.9 GB/day*
Nonimage product	ECS SDPS	2.8 GB/day
L1 product generation request	ECS SDPS	<100 MB/day
Trouble tickets	DHF	<100 MB/day
L1 product cancellation request	ECS SDPS	<100 MB/day
L1 production status request	ECS SDPS	<100 MB/day
L1 product accounting information	ECS MSS	<100 MB/day

* A 30-percent margin in L0R image (0.41 GB/image) is factored in to account for subinterval product requests that may overlap more than one WRS scene.

3.2 Nominal Operations

This section describes major operational activities performed by the LPGS in nominal mode.

3.2.1 L1 Typical Daily Activity

The subsections that follow provide a narrative of operations activities that may be performed for processing a product generation request on a typical day.

Table 3-2. LPGS Production and Distribution Requirements

Data	Interface	Output Volume
L0R product request	ECS SDPS	<100 MB/day
L1 product	ECS Insert Service	34.5 GB/day*
Characterization results**	IAS	<100 MB/day
Anomaly report	DHF	<100 MB/day
L1 product accounting	MSS	<100 MB/day
L1 production status information	ECS SDPS	<100 MB/day

*Based on an average L1G image (nonrotated, resampled to 25 m) volume of 1.3 GB.

** Characterization results are not expected to exceed 10 percent of calibration files daily input.

3.2.1.1 Preproduction

On a typical day, production operators review the current status of the processing queue for that day. L1 processing is performed on a FIFO basis, with the production planners able to promote work orders in the processing queue, as needed. Each day, the LPGS system automatically distributes a summary of the processing status to the ECS at the designated time entered into the system by the subsystem operator.

Each day, at a time designated and entered into the system by the subsystem operator, the LPGS automatically assesses system storage capacity. The LPGS maintains a minimum available storage volume for temporarily retained data. When the available LPGS temporary storage approaches the minimum, the LPGS purges from temporary storage L0R data that have expired or L1 data products that have been successfully retrieved by the ECS. L0R data have expired when the work order from which they were processed has been closed. System operators may select datasets that will be saved and not purged. The LPGS can display storage statistics to verify that sufficient storage is available to accommodate the receipt of data that will be processed for that day.

Periodically, the LPGS system receives trouble ticket updates from the DHF. These data are retained for reference in resolving anomalies and troubleshooting processing problems.

The LPGS receives product generation requests from the ECS, which uses product request identifiers to track the individual products or sets of products requested in one customer order. The product generation request information is forwarded to the processing control function for incorporation into the schedule. The LPGS creates a work order for each product generation request. The work order contains information extracted from the original product request, including a customer identification, processing parameters, product request identifier, and L0R data identifier. The work order is incorporated into the current processing queue as soon as it is complete.

The LPGS may also receive requests for cancelling a product generation request. In the case of receipt of a cancellation request, the processing control function automatically suspends processing of the affected work order. A production operator may review the work order and

manually confirm cancellation, causing termination of processing, closure of the work order, and transmission of cancellation confirmation to ECS. The subsystem can also be set to terminate processing automatically without operator intervention. After closure of a cancelled work order, the production operator can review production status to confirm reallocation of resources and manually select options to redistribute production status to the ECS.

After generation of the work order is complete, information identifying the required LOR data extracted from the work order is used to create an order for LOR data that is transmitted to the ECS. The LPGS then receives notification from the ECS that the LOR data will be transferred. The LPGS communicates with the ECS to coordinate transfer of the LOR data from a designated staging area and to notify the ECS that the data have been successfully received. When LOR data have been successfully received, production status is automatically updated to indicate that all required data are available and that processing may commence. Production operators can review production status and system monitoring displays and manually set image processing intermediate output options for a specific work order.

3.2.1.2 Production

As resources become available, image processing is initiated. When processing begins, processing parameters may no longer be modified. LOR products including the appended calibration parameter file or IC data, PCD, and MSCD are accessed from temporary storage for processing. According to operator selections, the production operator can specify system parameters before initiation of the processing flow that cause digital images and characterization statistics to be saved offline during specified intervals within the radiometric or geometric correction processing flow.

During L1 product generation, statistics generated during selected characterizations are collected for periodic transmission to the IAS. The LPGS also collects quality and assessment information that can be reviewed during postproduction analysis. Image quality is nominally verified automatically after processing has been completed. Postproduction analysis may include visual inspection of the digital image and generation of anomaly reports for transmission to the DHF if the image fails quality checks, as documented in operations procedures.

At any time during product processing, the EDC DAAC can request status of product processing requests. Work order status, which provides information on the processing requests, is updated on receipt of LOR data, at commencement of processing, and at successful completion of processing, as previously indicated. A product request status report is generated by extracting information from current work order status; the report is transmitted to the ECS in response to the status request.

3.2.1.3 Postproduction

After completion of L1 image generation, the work order and production status are updated. Metadata are created according to desired format, and other product components are assembled. Final product formatting is performed, and the quality of product components is verified. The L1 product components are transferred to the temporary storage area and a designated staging area in preparation for receipt by the ECS. The LPGS notifies the ECS of the availability of the L1

product using the product request identifiers and established message protocol. After the ECS has obtained and confirmed receipt of the L1 product, the data are marked for purging from the staging area. The LPGS then closes the work order and updates the work order accounting information. The LPGS periodically resolves or balances accounting information received from the ECS with accounting of work orders and products distributed.

Characterization results containing output from characterizations performed during all L1R product generation are routinely provided to the IAS and can help in anomaly resolution. Characterization results can include statistics obtained from characterizations for detector failures, coherent noise, and detector noise level.

On completion of the day's production schedule, production operators set controls and production parameters for processing performed during work shifts in which staff is reduced and systems are less attended.

3.2.2 Data Quality Analysis and Anomaly Resolution

Data quality thresholds are set by production operators before L1 image processing. The production operators select, through the operator interface, processing options and quality thresholds for an individual run or a set of production runs based on desired corrections and error limits. Images can be generated and distributed without visual inspection as long as quality thresholds documented in operations procedures and specified in user options are not exceeded.

3.2.2.1 Anomalies Found During L1 Processing and Postproduction Analysis

When anomalies are found during production or before distribution of images to the ECS, production analysts initially examine production quality reports to determine if the source of the anomaly is within the LPGS image processing system. If reprocessing the image does not resolve the anomaly, then options specified in the L1 product request and the processed L0R images are analyzed to identify a possible cause. A benchmark or calibration scene may be processed by the LPGS system operators to verify if there are problems with LPGS image processing software. If no anomalies are found in the L1 product generation request, L0R image, or L1 production process, then an anomaly report is forwarded to the DHF for analysis.

3.2.2.2 Response to Customer Report of Anomalies

When customers report anomalies found in received L1 products to the EDC DAAC, the EDC DAAC element responsible for user services and production processing and distribution initially issues a trouble ticket if a customer has not already done so. A Problem Investigator is assigned according to the established Problem Resolution Process. Investigators determine whether the reported product anomaly occurred as a result of media generation and distribution of the L1 product to the customer. If the analysts determine that the source of the problem was not in the ECS distribution operation, but in the L1 data, the trouble ticket is forwarded to the LPGS. LPGS production analysts examine the L1 data to verify that products were properly distributed to the ECS. The LPGS may then reprocess the image to determine whether the product is consistent with products received by the customer. If the reprocessed product is consistent with the anomalous product received by the customer, then the LPGS production analysts examine

production quality reports to assess whether thresholds were approached. If no anomalies are found in the L1 product generation request, L0R image, or L1 production process, the available information about the anomaly, including the trouble ticket and L1 output, is forwarded to the DHF for analysis.

3.2.3 Algorithm Update

Modifications to the LPGS processing algorithms are coordinated through software maintenance and sustaining engineering operations. Nominally, algorithm updates identified by software developers or IAS analysts are proposed to the LPGS Project Configuration Management Board (PCMB), which includes representation from LPGS and IAS organizations. The algorithm is integrated into the test baseline and tested in a model of the image processing subsystem in the development, test, and maintenance environment. Processing tests include duplicating processing of sample images for comparison of results between the test and production environments, as well as the IAS, if possible. It is assumed that the IAS and LPGS will maintain a common algorithm baseline. After control board review and approval of the algorithm update, the updated algorithm is scheduled for integration into the production baseline. Modification of the production baseline is scheduled for offpeak hours and includes regression testing that duplicates sample image processing performed in the test environment.

3.2.4 Reprocessing

Reprocessing of L1 images can be performed to respond to analysis of data quality assessments, to support anomaly resolution, to support algorithm integration and system regression test processing of benchmark calibration or known good scenes, and to recover from failures that resulted in loss of production images. Based on established operations procedures, reprocessing may be performed in response to postproduction quality assessment reports that indicate that thresholds have been exceeded. Production operators or analysts create reprocessing requests that are incorporated into the production processing queue. Any requests from the ECS for reprocessing L1 products are transmitted as new product generation requests to the LPGS. The position of the new product generation request within the processing queue can be modified to support expedited reprocessing.

3.2.5 Product Accounting

The Landsat 7 Mission Management Office (MMO) provides price information directly to the ECS, on a per-product basis, for Landsat 7 L1 ETM+ products at the start of the Landsat 7 mission. Pricing information updates are provided by the MMO, coordinating with the ECS, as needed. The interface for product price information distribution is described in the ICD between ECS and the Landsat 7 system (Applicable Document 3).

3.2.5.1 Product Price Estimation

Estimates of prices for products are provided on request to customers, as described in the ECS operations concept (Applicable Document 2).

3.2.5.2 Product Accounting Information Exchange

Periodically, LPGS provides the ECS with an accounting of data and documentation that have been received, processed, and distributed. The accounting management function maintains a record of volumes, counts, and date/time of L0R data products received from the ECS; L1R and L1G data products generated; and L1R and L1G data products and documentation distributed to the ECS. The LPGS automatically distributes accounting records to the ECS, on a periodic basis, according to an operator-specified interval. The operator can also select specific accounting records for distribution to the ECS at a designated date or time. The LPGS periodically receives from the ECS statistics and reports of LPGS-generated L1 ETM+ products and documents distributed by the ECS to customers. The statistics and reports include volumes, counts, and date/time of distribution of L1R and L1G products and documentation to customers.

3.2.6 Documentation and Production Software Distribution

At the start of the Landsat 7 mission, LPGS provides documentation to the ECS that describes the processing that may be performed on products that can be requested by users. This documentation can include descriptions of algorithms that may be applied, as well as descriptions of coordinate reference systems, output formats, orientation, grid cell size, resampling, and spectral channels that can be selected for processing. The ECS in turn uses this documentation to create information maintained by the ECS to populate guide and directory documents, which facilitate customers' ordering L1 products, or distributed to customers through the ECS advertising service. The ECS is provided with updates to the documentation according to the TBS LPGS configuration management plan. Production software is distributed to the ECS, which in turn can make the software available to customers through EDC's centralized documentation distribution and handling facilities.

3.2.7 System Test and Maintenance

The LPGS development, test, and maintenance functions provide an environment to support routine system maintenance and sustaining engineering. The functions provide redundancy for the image processing and can be used as a backup to support contingency operations and processing backlog workoff. These functions are used in development of software updates and provide an environment, including regression test data, for acceptance testing software modifications without impact to operations. Benchmark images are maintained to support anomaly resolution and testing. This environment can be used to support end-to-end testing of Landsat 7 digital image product ordering and processing without impact to operations, from search and order through the ECS to distribution of L1 image products to the customer.

3.3 Contingency Operations

This section describes major operational activities performed by the LPGS in response to system anomalies and failures, both internal and external to the LPGS.

3.3.1 LPGS Failure

A failure of the LPGS can be caused by failure of any LPGS subsystem that provides operational support of L1 image production, with the exception of the accounting and the development, test, and maintenance functions. LPGS failure can be detected by analyzing error messages received during scheduling, image processing, or image analysis. The LPGS system operators notify the EDC DAAC management, user services and production support offices, and IAS operators of the failure, either electronically or through a contingency medium or method. Operations procedures are implemented to isolate the failure within a specific LPGS subsystem. Operations procedures are followed to resolve and recover from the failure. As information becomes available, an estimate of the impact on production operations and of the time to return to full or partial operations may be provided. If the production planning functions are available, processing estimates may be made, and a tentative modification to the latest production status can be provided. After a failure is resolved, updated production status is provided. LOR data that have been lost or corrupted before processing are again requested from the ECS and processed according to the modified production status. L1 data that have been lost or corrupted before distribution to the ECS are reprocessed and then distributed.

3.3.2 Failure of Communication Links to the ECS

In the event of failure of communications links between the LPGS and the ECS, the DAAC manager, and the ECS system operator are notified of the failure by voice communications. Operations procedures are followed to determine which communication link failed. The LPGS distribution and message transmission functions are configured to discontinue transmission of L1 products and LOR data requests to the ECS. The LPGS production schedule continues to be followed, as much as possible, with continued processing of LOR data that are in working storage. If production can no longer continue because all online LOR data have been processed, then alternative methods can be used, if available, to request and retrieve LOR data. L1 data that have been produced are held in temporary storage until communications have been reestablished and verified. When communications have been reestablished, LPGS follows operations procedures to perform an accounting with the ECS to identify data lost because of failure of the communication link between the LPGS and the ECS.

Abbreviations and Acronyms

CCR	configuration change request
DAAC	Distributed Active Archive Center
DHF	Data Handling Facility
DSS	data server subsystem
ECS	EOSDIS Core System
EDC	EROS Data Center
EGS	EOS Ground System
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
EROS	Earth Resources Observation Satellite
ESDIS	Earth Sciences Data and Information System
ETM+	enhanced thematic mapper plus
FIFO	first in, first out
GB	gigabyte
GSFC	Goddard Space Flight Center
IAS	Image Assessment System
IC	internal calibrator
ICD	interface control document
IGS	international ground station
L0R	Level 0 radiometrically corrected
L1	Level 1
L1G	Level 1 geometrically corrected
L1R	Level 1 radiometrically corrected
Landsat	Land Satellite
LGN	Landsat ground network
LGS	Landsat 7 ground station
LPGS	Level 1 Product Generation System

LPS	Landsat Processing System
MB	megabyte
MMO	Mission Management Office
MOC	Mission Operations Center
MSCD	mirror scan correction data
MSS	management subsystem
NASA	National Aeronautics and Space Administration
PCD	payload correction data
PCMB	Project Configuration Management Board
SAT	Shift Along Track
SDPS	science data processing segment
SDR	system design review
SRR	system requirements review
SSR	solid state recorder
WRS	Worldwide Reference System